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Wireless Sensor Network application to Centralize the Water Tanks Filling & Monitoring System of Indore City

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Abstract: Wireless sensor networks (WSNs) are increasingly important for enabling continuous monitoring in many fields including environment sciences, water resources, ecosystems, and structural health and health-care applications. In this paper we have suggested an application and design of wireless sensor network for centralization of water tank filling & monitoring process. This system will be very economical in terms of the hardware cost, power consumption and labor utilization.

Keywords DTMF, Indore, Narmada, Wireless sensor network, Water Tank.

1. INTRODUCTION

Indore is the commercial capital of Madhya Pradesh. The water supply problem of the city assumed serious proportions in the 1970s and a plan to pump water up from the Narmada river 70 kms away and at a level 500 meters below was drawn up. Pipelines draw water from the river for the city at exorbitant costs. The distribution of drawn water require significant time and monitoring. The total water supply for Indore according to the Indore Municipal Corporation (IMC) is 252.5 million liters per day (MLD) from four sources and their actual respective contributions in 2011 are as follows[2] : (Table 1)

S.N.	Water Source	Quantity Drawn in MLD
1	Three Phases of Narmada	200 MLD
2	Yashwant Sagar Reservoir on Gambhir River	22 MLD
3	Bilawli Tank	3.5 MLD
4	Tubewells, Open Wells and Handpumps	27 MLD

Table-1: Indore Water Sources and Quantities

The major part of total supply is Narmada water. This water pumped from the river and then distribute to all the zonal overhead water tanks of city for further distribution. The distribution of Zonal tanks can be seen in Fig. 1. The Indore has total 46 Overhead tanks and all the tanks are situated at significant distance to each other. Also the tanks need to fill every day with sufficient quantity and this requires men power and electrical power.

As with the Waterworks H.O., the major component of revenue expenses for the Narmada Project (Division I & II) is **salaries & wages to the staff** (25.94% of total). This component is entirely borne by the Public Health and Engineering Department (PHED) as annual administrative grants. Other important expense components include the purchase of chemicals, maintenance of plant, machinery, **pipelines & overhead tanks, electricity expenses** [3].

As the Monitoring required the men power which reflects in terms of cost. There is always probability of human error which causes to tank overflow. This overflow waste water and electricity too.

This work is proposed to overcome the aforementioned problems by automatizing the zonal tanks filling process using WSN.

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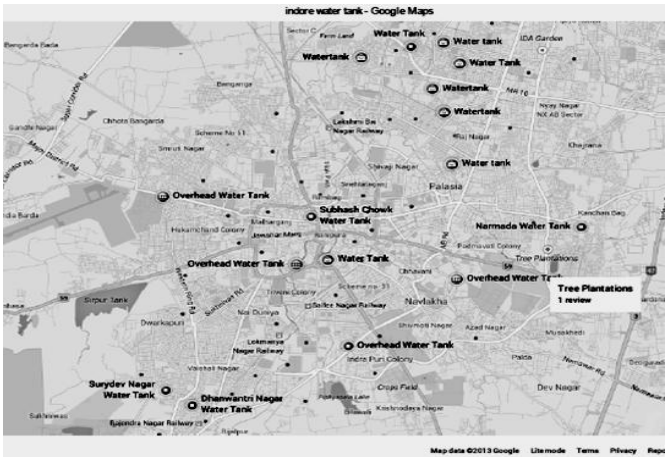

Fig.1: Water Tank situation in Indore (Source Google map: taken on 01/08/2013)

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location [4].

DTMF is a generic communication term for touch tone (a Registered Trademark of AT&T). The tones produced when dialing on the keypad on the phone could be used to represent the digits, and a separate tone is used for each digit. DTMF dialing uses a keypad with 12/16 buttons. Each key pressed on the phone generates two tones of specific frequencies, so a voice or a random signal cannot imitate the tones. One tone is generated from a high frequency group of tones and the other from low frequency group [4,10,11]. The frequencies generated on pressing different phone keys are shown in the Table 2.

Table-2: DTMF Frequency Assignments

		Col 1	Col 2	Col 3	(Col 4)
		1209	1336	1477	1633
Row 1	697	**1**	**2**	**3**	**A**
Row 2	770	**4**	**5**	**6**	**B**
Row 3	852	**7**	**8**	**9**	**C**
Row 4	941	*	**0**	#	**D**

The proposed work consists of two parts: Master unit (MU) and Sensor units (SU). This system is suitable for the complex and large-scale water distribution systems such as from reservoirs, lakes, rivers, swamps, and shallow or deep ground waters. This paper is devoted to the explanation and illustration for automation of water distribution, monitoring and control system design.

More specifically, we developed a Microcontroller based water level sensor unit which also can perform electrical switching function. As the water level management approach would help in reducing the power consumption and prevent the water overflow. Furthermore, it can indicate the amount of water in the tank.

There are many problems associated with water tank monitoring and management:

- Usually in an urban area there is large number of water tanks corresponding to different localities, hence the routine monitoring of all water tanks is not easy, it's really a tough task to do.
- Moreover a large number of operators and workers may be required in order to manage the water tanks functioning.
- Earlier, when the water get finished in the water tanks, we cannot get any information about that and water supply got interrupted and on other hand the excess & continuous supply of water causes overflow, hence causes wastage of water.
- Sometimes the medium through which the water is supplied get damaged and it causes the interruption in supply. We cannot detect the reason for this kind of problem easily.
- While filling the tank there must be someone to take an eye for the complete time until tank got fully filled, so continuous monitoring is requires.

So our work is to overcome all these problems.

2. SYSTEM DESIGN AND IMPLEMENTATION

The system design is basically differentiated as: Master Unit and Sensor Unit.

2.1 Master Unit Designing

The Master unit plays an important role of monitoring whole circuit so it should be designed as a fully functioning device, its main role is to establish network with any one of the SUs, check the status of water level at the related tank, display the water level on MU for

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the user and maintain the suitable water level by taking input from the user.

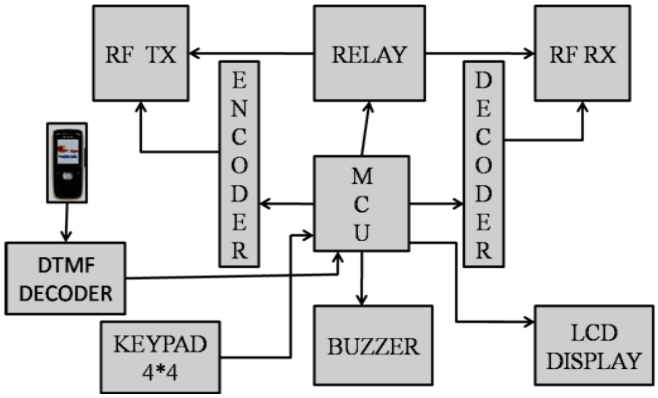

Fig.2: The functional block diagram of Master Unit situated at central zonal office.

We had selected here AT89c51 Microcontroller as the processor of the MU.

The design of master unit includes the following units:

Microcontroller –The Atmel AT89c51 is a low power high performance 8 bit microcontroller. The device is manufactured using Atmel's high density nonvolatile memory technology. The AT89C51 provide the following standard features: 4K bytes of Flash memory, 128 bytes of RAM, 32 I/O lines, two 16-bit timer/counters, a five vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator and clock circuitry it is a highly flexible and cost effective solution to many embedded control applications[11].

2.2 Slave unit (SU) Designing

The slave unit is capable to wirelessly communicate with MU through RF modules. Slave unit uses the same design as MU, excluding the LCD and Key pad. It has water level sensors and Motor/Valve control circuit on- board

Water Level Sensor Unit- At the Zonal overhead tanks water levels are marked from Empty level to 10000 liters in steps. For sensing purpose we had connected copper electrodes and these electrodes are connected to microcontroller pins and by this we check the status of water level in the tanks.

Motor/Valve Control Circuit- This Circuit uses Relays and Relay driver IC to control over the Motor or Valve which then control the input water flow.

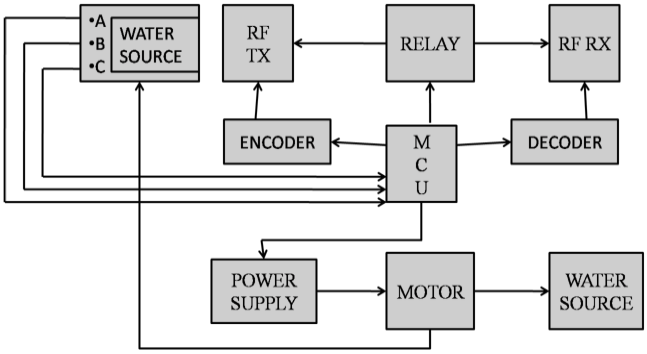

Fig.3: The functional block diagram of Sensor Unit which will be installed to the zonal overhead water tanks.

3. METHODOLOGY

The operator can operate the system either of on-system keypad or with his cell phone just by dialing and sending the DTMF commands over the GSM network [4]. When system will initialize, all the TX-RX pairs get activated. The operator first selects the SU. MU sends a unique code to all the SU in range, only the matched node will acknowledge. If the desired SU situated far away to MU, than the code will routed via intermediate SUs. After receiving the code, SU sense the water level and sends the acknowledgement to MU which then display on LCD.
In the filling process the operator enters the amount of water in liter for a particular Zonal Tank and then sends to the selected SU or all the SUs. The SU then switch on the Motor or Electric Valve and continue monitor the level. When the water filled to desired level the SU sends an acknowledgement message to MU and MU indicates the process completion via LCD display and buzzer.

Multihop Communication
A focus of the recent work on WSN has been on multihop communication. Multihop communication is the transfer of data and commands between two nodes that are not in the direct radio range, using intermediary nodes. Multihop communication is essential for scalability of low-power wireless sensor

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networks be cause single-hop networks are spatially limited by the radio range and cannot span long distances without a large power supply. However, multihop presents major challenges to several aspects of a WSN. The routing of data packets in a single-hop network only needs a queue for all of the nodes to transmit their packets directly to a base station. In a multihop network, routing is more complex because each node has to determine how to find the most efficient way to forward packets to the base station and coordinate transmission of packets received from other nodes. The routing needs to reconfigure dynamically for robustness if a node fails and is no longer able to serve as an intermediary such as because
of radio interference for multihop communication.

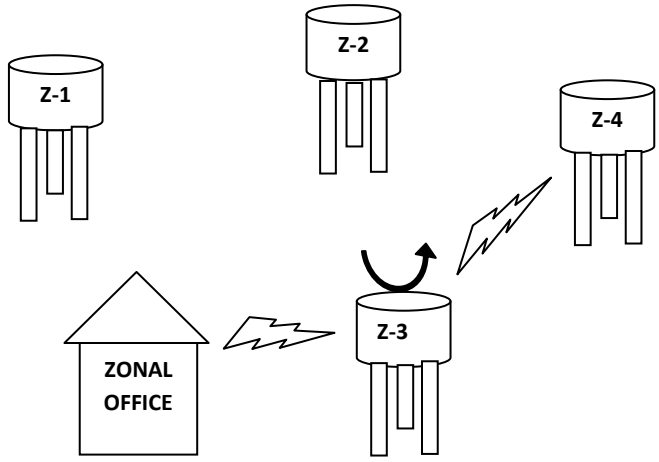

Fig.4 Working Methodology. MU installed at Zonal office and SUs are installed on zonal tanks (Z1-Z-4). Also Z-3 work as router for Z-4.

4. SYSTEM SOFTWARE DESIGN

After the system power up, the WSN network initialization software module will begin to take effect, initializing protocol stack, check the wireless network links, Initiates all the SUs. When the initialization completed, the SU will be allowed to Connect into the network, they can send water level status data, accordingly we can view the data from all the SUs and also the data transmitted on the LCD. Microcontroller has been programmed to automatically linkup to all the SUs through RF link after the SU selection is done and then the controller automatically sends the status of water level from the particular SU, which is displayed on the MU's LCD. Coding/debugging of complete system Program is done by using Keil uVision2 Ver2.40a software and then burned into MCUs.
The following steps are involved during the software development process:

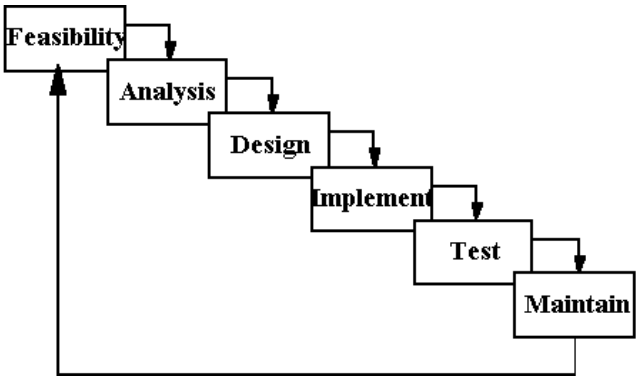

Fig 5. Water flow model of Software Development cycle.

5. CONCLUSION

The application design of Wireless Sensor Network for Centralized Water tank filling and monitoring Process makes it very simple user friendly and very cost effective. The designed hardware structure is downsizing, small volume, and small power consuming. The wireless sensing network, we established is characterized by self organization and adaptive system. This water monitoring system has the virtue like small power consuming, data transmission reliable, and low cost. The wireless sensing network technology can be used to every walk of life and this system can be used in production. After a nominal installation cost it make the overall process simple and cheap.

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